Point Lab

Calculation 1. This example illustrates how average SO_2 emissions can be calculated based on raw CEM data.

Boil Emissions (CEM Data) -Assumed Operating Parameters

Period	**O_2 (%V)**	**SO_2 (ppmv)**	**Stack Gas Flow Rate (dscfm)**
11:00	2.1	1,004.0	155,087
11:15	2.0	1,100.0	155,943
11:30	2.1	1,050.0	155,087
11:45	1.9	1,070.0	154,122
12:00	1.9	1,070.0	154,123
Average	2.0	1,058.8	155,272

HHV: Fuel heating value: 18,000 Btu/lb
SO_2: Molecular weight: 64 lb/lb-mole
V: Molar volume: 385.5 ft^3/lb-mole at 68°F and 1 atm
Q_f: Mass fuel throughput: 46,000 lb/hr
OPHrs: Total annual hours of operation: 5,400 hours

<u>Calculating Hourly Emissions of SO_2</u>

$$E_{SO2} = \frac{(C\ x\ MW\ x\ Q\ x\ 60)}{(V\ x\ 10^6)}$$

Where:
C: Parts per million by volume dry air (ppmvd)
MW: Molecular weight in lb/lb-mole
Q: Flow rate in dry standard cubic feet per minute (dscfm)
V: Molar volume in cubic feet (ft^3)/lb-mole

Calculating Heat Input

$$H_{in} = \frac{(Q_f \ x \ HHV)}{(10^6)}$$

Developing SO_2 Emission Factors

An SO2 emission factor expressed as lb/MMBtu is calculated as follows:

$$EF_{SO2} = \frac{E_{SO2}}{H_{in}}$$

Calculating Annual SO_2 Emissions

Annual SO_2 Emisisons = Hourly SO_2 Emissions x O_pHrs

Calculation 2. Boiler Emissions (Source Testing Data)

This example illustrates the procedure to estimate lead emissions from a boiler using stack testing results.

Assumed Operating Parameters

The results of these stack sampling test runs show that the average concentration of lead (Pb) in the stack gas is 0.0005 pound per dry standard cubic feet (lb/dscf) and the average stack gas volumetric flow rate is 51,700 dry standard cubic feet per minute (dscf/min). The boiler operates 5,840 hours per year, and is equipped with a multicyclone.

Calculating Pb Emissions

Pb Emission lb/hr = Pb Concentration x Stack Gas Flow Rate

Annual Pb Emissions = Pb Emission lb/hr x Operating hours per year x 1 ton/2,000 lb = tpy

<u>Calculation 3</u>. Copper Coil Manufacturing (Material (Mass) Balance)

This example illustrates the use of material (mass) balances as a method for estimating emissions from a metal rolling unit that processes copper coil. Prior to a rolling step, copper coil is sprayed with oil for lubrication and heat dispersion. After rolling, the copper coil is sent to an annealer which has been shown to destroy 85 percent of the oil during the heat treatment of the copper oil. Negligible amounts of oil remain on the copper coil after annealing. The oil is assumed to be 100 percent VOC. The VOC emissions associated with this process occur from volatilization of lubricating oil during its application prior to rolling as well as the undestructed oil exhausted from the annealer.

<u>Assumed Operating Parameters</u>

Mass of copper coil processed:	5,000 kg
Mass of copper coil and oil sent to annealer	5,075 kg
Mass of lubricating oil sprayed onto the copper	3,000 kg
Mass of lubricating oil recovered:	2,800 kg

<u>Estimating Emissions</u>

The general formula to complete a material balance is represented by:

Input + Generation - Output - Consumption = Accumulation

where:

Input:	Mass entering the process
Generation:	Mass produced in the process
Output:	Mass exiting the process
Consumption:	Mass consumed in the process
Accumulation:	Mass that builds up within the process

For this example, the parameters listed above are described as:

Input:	Mass of lubricating oil applied (3,000 kg)
Generation:	Not applicable/no material generation (0 kg)
Output:	Mass of oil lost as an emission
Consumption:	Mass of oil destroyed in the annealer
Accumulation:	Mass of lubricating oil recovered (2,800 kg)

The estimate for the Consumption parameter is calculated from the mass of copper coil processed, the mass of copper coil and oil sent to the annealer, and the oil destruction efficiency as it is exposed to high temperatures in the annealer.

Consumption = (Mass of coil & oil to annealer - Mass of coil processed) x 85 percent

After simplifying the material balance formula the estimate of the Output (emissions) from this process is:

Input - Output - Consumption = Accumulation

Or

Output = Input - Consumption - Accumulation

<u>Calculation 4</u> - Boiler Emissions (Fuel Analysis)

This example illustrates how SO_2 emissions from fuel combustion can be calculated using fuel analysis results.

<u>Assumed Operating Parameters</u>

Sulfur content of fuel:	1% by weight
Fuel throughput:	5,000 lb/hr
Hours of operation:	8,760 hours/year

Calculating SO2 emissions:

The basic equation in fuel analysis emission calculation is:

$$\mathbf{E = Q_f \text{ x pollutant concentration in fuel x } (MW_p/MW_f)}$$

Where:

Q_f = Throughput of fuel in lb/hr
MW_p = Molecular weight of pollutant emitted (lb/lb-mole)
MW_f = Molecular weight of pollutant in fuel (lb/lb-mole)

In this example, MW_p = 32 + (16 x 2) = 64 lb/lb-mole
MW_f = 32 lb/lb-mole

Therefore, E_{SO2} =

Calculation 5. Coal-fired Industrial Boiler (Emission Factors and Temporal Allocation)

This example illustrates the procedures to calculate emissions from an industrial boiler firing anthracite coal.

Assumed Operating Parameters

Coal type:	Anthracite
Annual coal consumption:	928,000 tons per year (tpy)
Ash content of coal:	7 percent
Sulfur content of coal:	1.87 percent

Seasonal throughput fractions:	Winter	=	50%
	Spring	=	20%
	Summer	=	10%
	Fall	=	20%

Particulate emissions are controlled with a 75 percent efficient cyclone.
Sulfur oxides emissions are controlled with a 93 percent efficient limestone injection system.

Boiler Type: Traveling grate stoker

AP-42 Emission Factors

Section 1.2 of AP-42 provides emission factors for pollutants from anthracite coal combustion in stoker fired boilers:

Total organic compounds (TOC)	=	0.3 lb/ton (Table 1.2-6)
Particulate Matter (PM)	=	0.8A lb/ton for PM-filterable and 0.08A lb/ton for PM-condensible where A is the ash content of coal in weight percent (Table 1.2-3)
Lead (Pb)	=	8.9E-03 lb/ton (Table 1.2-3)
Nitrogen oxides (NO_x)	=	9 lb/ton (Table 1.2-1)
Sulfur dioxides (SO_2)	=	39S lb/ton where S is the weight percent of sulfur in the coal (Table 1.2-1)
Carbon monoxide (CO)	=	0.6 lb/ton (Table 1.2-2)

Estimating Uncontrolled Emissions

The general equation for estimating uncontrolled emission of TOC, Pb, NO_x, CO, and CO_2 from anthracite coal combustion in boilers is as follows:

Boiler Emissions = Annual Coal Consumption x Emission Factor

TOC =

Pb =

NO_x =

CO =

The general equation for estimating uncontrolled emissions of PM from anthracite coal combustion in boilers is as follows:

PM Emissions = Annual Coal Consumption x (Emission Factor x Coal Ash Content)

PM Filterable = 928,000 tons/year x (0.8 lb/ton x 7) = 5,196,800 lb/year = 2,598 tpy
PM Condensible= 928,000 tons/year x (0.0816 lb/ton x 7) =519,680 lb/year =259.8 tpy

Total PM = 2,598 tpy + 259.8 tpy = 2,857.8 tpy

The general equation for estimating uncontrolled emissions of SO_2 from anthracite coal combustion in boilers is as follows:

SO_2 Emissions = **Annual Coal Consumption x (Emission Factor x Coal Sulfur Content)**

SO_2 Emissions =

Estimating Controlled Emissions

Particulate emissions are controlled with a 75 percent efficient cyclone and SO_2 emissions are controlled with a 93 percent efficient limestone injection system. The general equation for estimating controlled emissions of PM and SO_2 is as follows:

Controlled Emissions = Uncontrolled Emissions x (1 - Efficiency/100)

Total PM =

Total SO_2 =

Temporal Allocation of PM Emissions

The general equation for estimating season emissions is as follows:

Seasonal emissions = Seasonal throughput fraction x annual emissions

Therefore:

Winter emissions of PM =

Spring emissions of PM =

Summer emissions of PM =

Fall emissions of PM =

Area Lab

Calculation 1. Estimating County Level Wood Usage (Top-Down Approach)

This example illustrates the procedure to allocate residential wood consumption to the county level using a top-down approach.

Assumed Operating Parameters

Wood used for residential energy in State A: 622,000 cords
(Obtained from the EIA's State Energy Data Report)
Number of households using wood as primary fuel in State A: 80,047
(Obtained from the U.S. Census data on house heating fuel)
Number of households using wood as primary fuel in county of study: 1,242 households

Allocating Wood Used to the County of Study

County Wood Use = State wood use x county households/state households

County Wood Use =

Calculation 2. Open Burning of Household Waste (Local Survey Results)

This example illustrates the procedure to scale up the results of a survey performed on a sample of households to estimate emissions from the entire county.

<u>Assumed Operating Parameters</u>

A survey of 200 households in a rural portion of County A showed that 6.7% of the households use burn barrels to dispose of combustible household waste. The survey was conducted in locations where no garbage pickup services are available. The survey also showed that:

- The average waste generated per household is 6.75 lb/day
- The waste generated that is combustible waste is 80%

The U.S. Census data also shows that 17,502 households are in the rural portion of County A. A telephone conversation with the County Planning Department revealed that 15% of the households in rural areas have access to public or private garbage pickup services.

<u>Scaling Up Survey Results</u>

A number of households in rural areas with no access to garbage pickup service = 17,502 x 0.85 = 14,877 households

Number of households that use burn barrels = 14,877 households x 6.7/100 = 997 households

<u>Estimating Activity Level in County (Combustible Waste)</u>

Total waste generated by households that use burn barrels =
Number of households using burn barrels x average waste generated per household

Total combustible waste generated by households that use burn barrels = Total waste generated by households using burn barrels x percentage of generated combustible waste

From AP-42, Table 2.5-1, the emission factors fro open burning of municipal refuse are:

CO	85 lb/ton
PM	16 lb/ton
SO_x	1 lb/ton
NO_x	6 lb/ton
TOC	21.5 lb/ton

Therefore, daily emissions from open burning of household waste in the County are:

Daily Emissions = Emission Factor x Total Combustible waste generated (in tons)

CO =

PM =

SO_x =

NO_x =

TOC =

Calculation 3. State I Gasoline Marketing (Rule Effectiveness/Rule Penetration)

This example illustrates the application of rule effectiveness and rule penetration in calculating VOC emissions from filling an underground gasoline storage tank.

Assumed Operating Parameters

Total county throughput	500,000 gal/day
Tank filling method	slash filling
Filling method central efficiency	95%
Stage I gasoline marketing emission factors	11.5 lb/1,000 gal throughput (From AP-42, Table 5.2-7)
RE is assumed to be	80%
RP is assumed to be	93% (fraction of throughput that will be subject to control)

Calculating Emissions

$$E = A \times EF \times (1 - C \times RE \times RP)$$

A = 500,000 gal/day
EF = 11.5 lb/1,000 gal
C = 0.95
RE = 0.8
RP = 0.93

Therefore, E =

Calculation 4. Surface Coating Operations (Mass Balance)

This example illustrates the procedures to calculate VOC and PM emissions from surface coating operation at a wood furniture plant.

Assumed Operating Parameters

Coating Type	A
Coating Density	7.5 lb/gal as applied
Coating Density of Volatile Content	6.2 lbs/gallons as applied
Coating Usage	1,600 galls per year
Spray Booth Type	Dry-filler spray booth
Spray Gun Transfer Efficiency	60%
Dry Filter Collection Efficiency	99%

Estimating VOC Emissions

VOC (tpy) = Volatile content density x annual usage
VOC (tpy) =

Estimating Uncontrolled PM Emissions

Coating density of solid content = Density of coating A - Density of volatile content

Uncontrolled PM emissions = Density of solid content x annual usage x (1 - transfer efficiency)

Estimating Controlled PM Emissions

Controlled PM emissions = Uncontrolled PM x (1 - Control efficiency)

Calculation 5. Surface Coating (Per Employee Emission Factor)

This example illustrates the procedure to estimate VOC emissions from surface coating using a per-employee emission factor.

Assumed Operating Parameters

A survey was conducted on a subset of facilities that manufacture wood furniture. The survey indicated that the average coating usage per employee is 12 gal/year. In addition, the survey results indicated that the average coating applied has a density of 7.5 lb/gal and is 45% VOC by weight.

Calculating Area Sources Employment (Adjusting for Major Sources)

Surface coating operations occur at facilities designated as point sources and at smaller facilities designated as area sources. However, in order to avoid double counting, emissions from those facilities that are designated as point sources should not be included in the area source inventory. One approach to reducing the effect of double counting is to subtract the activity occurring at the point sources. Therefore, in this example, total employment in surface coating in the inventory is reduced by employment at the point sources. The resulting employment is assumed to be the employment at area sources involved in surface coating operations.

Area source employment = total employment from County Business Patterns - major source employment from permit applications.

2,500 - 1,600 = 900 employees

Calculating area source emissions

VOC emissions from area sources = area source employment x average coating usage x % VOC coating density

VOC emissions from area sources =

Calculation 6. Emissions from Benzene Loading Operations (Emission Factors)

This example illustrates the AP-42 calculation procedures, at a benzene manufacturing facility, for estimating emissions from transfer of benzene using dedicated, submerged loading transfer trucks equipped with condensers for product recovery.

<u>Assumed Operating Parameters</u>

Transfer truck volume	9,200 gals
Benzene loading temperature	80°F
Vapor recovery efficiency	95 percent
Annual benzene loaded	820,000 gals

<u>AP-42 Emission Factors</u>

Emissions from uncontrolled loading operations can be estimated using the following AP-42 equation obtained from Section 5.2 of AP-42:

$$\mathbf{L_L = 12.46 \times \frac{S \times P \times M}{T}}$$

Where:

L_L	=	loading loss, in lb/10^3 gal of liquid loaded
M	=	molecular weight of vapors, in lb/lb-mole, obtained from Table 7.1-2
P	=	true vapor pressure of liquid loaded in psia, obtained from Table 7.1-2
T	=	temperature of bulk liquid loaded, in °R (°F + 460)
S	=	saturation factor, obtained from Table 5.2-1 and function of cargo carrier and mode of operation

From Table 7.1-2

M	=	78 lbs/lbs-mole
P	=	2 psia
T	=	80°F = 80°F = 460 = 540°R

From Table 5.2-1 for a submerged loading, dedicated, normal service operations, S = 0.6

Based on the above, the emission factor for benzene loading operations is: